APPENDIX 5-H

SLOPE STABILITY ANALYSIS

Dames & Moore
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TWX: 910-925-5692 Cable address: DAMEMORE

December 29, 1980

Mr. Wendell Owen
CO-OP Mining Company
Box 300
Huntington, Utah 84528

Dear Mr. Owen:

Report
Geotechnical Consultation
Bear Creek Portal
Near Huntington, Utah
For CO-OP Mining Company

INTRODUCTION

The purpose of this report is to discuss the stability of side-cast fill material placed during construction of the access road to the CO-OP Mining Company Bear Creek Portal. The scope of our consultation was formulated in discussions with Mr. Owen and consisted of a brief field reconnaissance, collection of a sample of the fill material, limited laboratory testing and preparation of this report.

The Bear Creek Portal is located in the SW 1/4, SW 1/4, S. 24, T. 16S., R. 7E., Emery County. Several abandoned facilities from a previous mining effort exist near the Portal. We understand that the CO-OP Mining Company is in the process of re-opening the old mine and that the existing old Portal will be used for ventilation of the new mine. The mine is located in a steep slope in the Wasatch Plateau; access to the Portal is by a typical unsurfaced access road constructed by conventional side-cast methods.

We understand that a violation of the federal regulations (Section 717.14 in the Federal Register, Vol.42, No.239, P.62695, issued December 13, 1977) was issued by the State Division of Oil Gas and Mining to CO-OP Mining Company. Part (c) of this section states that surface operations on steep slopes (20 degrees or more) "shall be conducted so as not to place any material on the down slope below road cuts, mine workings or other benches, other than in conformance with part (a)(1)" of Section 717.14. Part (a)(1) states that fills shall achieve a minimum static safety factor of 1.5.

The slope where the Bear Creek Portal is located is steeper than 20 degrees and the only feasible way to construct the access road is by conventional side-cast methods. Therefore, the static factor of safety of the side-cast material is the key issue.

DISCUSSION

The material being excavated and forming the side-cast fill is gravel and cobble sized pieces of silty sandstone in a sandy and silty clay matrix. Calcium carbonate derived from the cement in the sandstone is also present. The results of a partial grain size analysis are tabulated below:

SIEVE NUMBER	PERCENT FINER BY WEIGHT
#4	72.2
#40	64.0
#200	37.2

The results of an Atterberg Limit determination performed on the material finer than the number 200 sieve are tabulated below:

LIQUID LIMIT(%)	PLASTIC LIMIT (%)	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
30.5	15.6	14.9	CL

During our reconnaissance, we examined the access road leading to the Trail Canyon Portal in Section 22. This road is in virtually indentical conditions to the road leading to the Bear Creek Portal. Some of the side-cast fill near the Trail Canyon Portal is 25 years old; the youngest of it is about 10 years old. The side-cast fill material near the Trail Canyon Portal is nearly everywhere sloping at 35 degrees (approximately 1-1/2 horizontal to 1 vertical).

The side-cast material appears to be performing in a satisfactory manner. In many places, the side-cast material appears to be very similar to natural slopes between nearly vertical exposures of resistant sandstone. Very minor gullies and slumps are present locally. Vegetation is becoming established on some of the slopes.

The surface of the side-cast material is quite firm and difficult to walk on because boot heels don't penetrate. We believe that the reason the surface is so firm is related to the clay and the calcium carbonate in the soil. The clay gives the soil cohesive strength and the calcium carbonate tends to cement the soil particles together.

The calcium carbonate cement in the soil is probably a significant constituent in the safety factor of side-cast fill material which has remained stable for 25 years in a situation identical to the access road leading to the Bear Creek Portal.

CONCLUSION

Based on observations made during our reconnaissance and the discussions presented above, it is our opinion that the side-cast material located adjacent to the access road leading to the Bear Creek Portal will behave in a manner similar to the side-cast material located adjacent to the access road leading to the Trail Canyon Portal. Since the material near the Trail Canyon Portal has been grossly stable for 10 to 25 years as determined by its performance, we believe that the material placed during construction of the Bear Creek Portal access road will also be grossly stable.

Consequently, we believe that the stability concern identified in the regulations can best be addressed by the empirical evidence of the performance of similar material in a similar situation rather than a calculated factor of safety.

We trust that this report satisfies your present needs. If you have any questions or require additional discussions or information, please contact us.

Very truly yours,

DAMES & MOORE

William J. Gordon
Associate
Professional Engineer No. 3457
State of Utah

Jeffrey R. Keaton
Engineering Geologist

WJG/jrk/kc

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February 20, 1981

Mr. Wendell Owen
Co-op Mining Company
Box 300
Huntington, Utah 84528

Dear Mr. Owen:

Summary Report
Slope Stability Analyses
Bear Creek Portal
Access Road
Near Huntington, Utah
For Co-op Mining Company

INTRODUCTION

This report summarizes the results of our stability analyses of the slopes along the Bear Creek Portal Access Road located northwest of Huntington, Utah.

PURPOSE AND SCOPE

The purpose and scope of this study were planned in discussions between Mr. Wendell Owen of Co-op Mining and Mr. Bill Gordon of Dames & Moore. In general, the purpose of this investigation was to analyze the static factor of safety of the side-cast cut and fill slopes along the Bear Creek Portal Access Road.

BACKGROUND

The Co-op Mining Company is in the process of reopening an abandoned coal mine at the Bear Creek Portal. Several abandoned facilities from a previous mining effort exist near the portal. We understand that the existing old portal will be used for ventilation of the new mine. The mine is located on a steep slope in the Wasatch Plateau and access to the portal is by a typical unsurfaced access road constructed by conventional side-cast methods.

Co-op Mining Company was issued a citation by the Department of Natural Resources Division of Oil, Gas, and Mining. The nature of the violation was with regard to the placement of side-cast cut and fill material on steep slopes (20 degrees or more). Regulations require that such fills achieve a minimum static factor of safety of 1.5.

An engineering geologist from Dames & Moore previously visited the site and performed a reconnaissance survey of the area and sideslopes in question. Laboratory tests have been performed on samples of the side-cast cut and fill material obtained at the site. These laboratory tests included sieve analyses and Atterberg Limits. The results of these laboratory tests, a discussion of our site reconnaissance survey, and a summary of our conclusions were presented in a report dated December 29, 1980*.

*"Report, Geotechnical Consultation, Bear Creek Portal, Near Huntington, Utah, For Co-op Mining Company."

SITE CONDITIONS

The general location of the Bear Creek Portal Access Road is shown on Plate 1, Plot Plan. Side-cast cut and fill areas as determined by others are also indicated on Plate 1. The slopes in the area of the Bear Creek Portal are generally steeper than 20 degrees and the access road has been constructed by conventional side-cast methods. The material being excavated and forming this side-cast cut and fill typically consists of fine and coarse gravel and cobble sized pieces of silty sandstone in a sandy and silty clay matrix. Calcium carbonate derived from the cement in the sandstone is also present.

The surface of the side-cast material is quite firm, which we believe to be related to the composition of clay and calcium carbonate in the soil. The clay acts as a binder and gives the soil cohesive strength and the calcium carbonate tends to cement the soil particles together. As discussed in our previous letter, the calcium carbonate cement in the soil probably provides a significant component of the factor of safety of the side-cast fill material. However, the determination of a numerical value for the influence of the calcium carbonate cementation would be very difficult to accurately determine.

SOIL PROPERTIES

Based on the results of laboratory tests performed on samples of the side-cast cut and fill material from the Bear Creek Portal site and our experience with similar soils, we have assumed the following soil properties:

Side-Cast Fill Material

Angle of Internal Friction	$\phi = 26^{\circ}$
Cohesion	C = 350 psf
Unit weight soil	δ = 98 pcf

Natural Soils

Angle of Internal Friction	$\phi = 26^{\circ}$
Cohesion	C = 700 psf
Unit weight soil	δ = 120 pcf

SLOPE STABILITY ANALYSIS

To aid in evaluating the stability of the side-cast cut and fill material of the Bear Creek Portal Access Road, a computer slope stability analysis was performed. The computer analysis utilized a simplified Bishop's Method in computing the long-term static factor of safety of the slopes. Due to the limited laboratory and field data, and the uncontrolled method in which side-cast cut and fill materials are placed, ultra conservative soil strength parameters were used in the computer analysis. A Geometric cross-section of a critical section utilized in the analysis is shown on Plate 2, Slope Cross Section. It was also assumed that a phreatic water surface would not develop in the slopes of the embankment.

The computer program analyzed the slope stability by searching a specified coordinate grid area for the center of the circle having the lowest factor of safety. The slope stability analyses was performed using a total of four separate coordinate grid areas. The number of trial failure arc centers analyzed in each of these four areas varied from 12 to 63. As indicated on Plate 2, this analysis indicated a minimum static factor of safety varying from 1.43 to 2.15.

Copies of the results of the computer analysis for each coordinate grid area are included with this report.

DISCUSSIONS AND RECOMMENDATIONS

GENERAL

Supporting data upon which our recommendations are based have been presented in the previous sections of this report and in the previous Dames & Moore report dated December 29, 1980.

SLOPE STABILITY

The computer slope stability analysis indicates a minimum static factor of safety varying from 1.43 to 2.15 for the trial arcs analyzed.

It should be noted that the factor of safety of the trial arc which cuts deep into the slope does not consider the presence of bedrock, increasing strength of the natural soils with depth, or the effect of the calcium carbonate cementation in the soil. If the above were incorporated into the analysis, the factor of safety would be significantly higher.

Stability of the slopes will be influenced by the degree of saturation of the existing soils. Therefore, surface drainage must be channeled to minimize runoff over the slopes. However, during wet periods of the year, small localized slides and sloughs should be anticipated along the slopes. However, these occurrences should be minor. The performance of these side-cast cut and fill slopes is anticipated to be similar to virtually identical side-cast cut and fill slopes along the nearby road leading to the Trail Canyon Portal. These slopes have been stable since their construction, varying from 10 to 25 years ago.

Based on our slope stability analysis and observations made during our reconnaissance visit to the site, it is our opinion that the side-cast fill material located along the Bear Creek Portal Access Road generally has a long-term static factor of safety of 1.5 or greater and will perform in a satisfactory manner.

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We appreciate the opportunigy of performing this service for you. If you have any questions or require additional information, please contact us.

Very truly yours,

DAMES & MOORE

William J. Gordon
Associate
Professional Engineer No. 3457
State of Utah

Douglas G. Beck

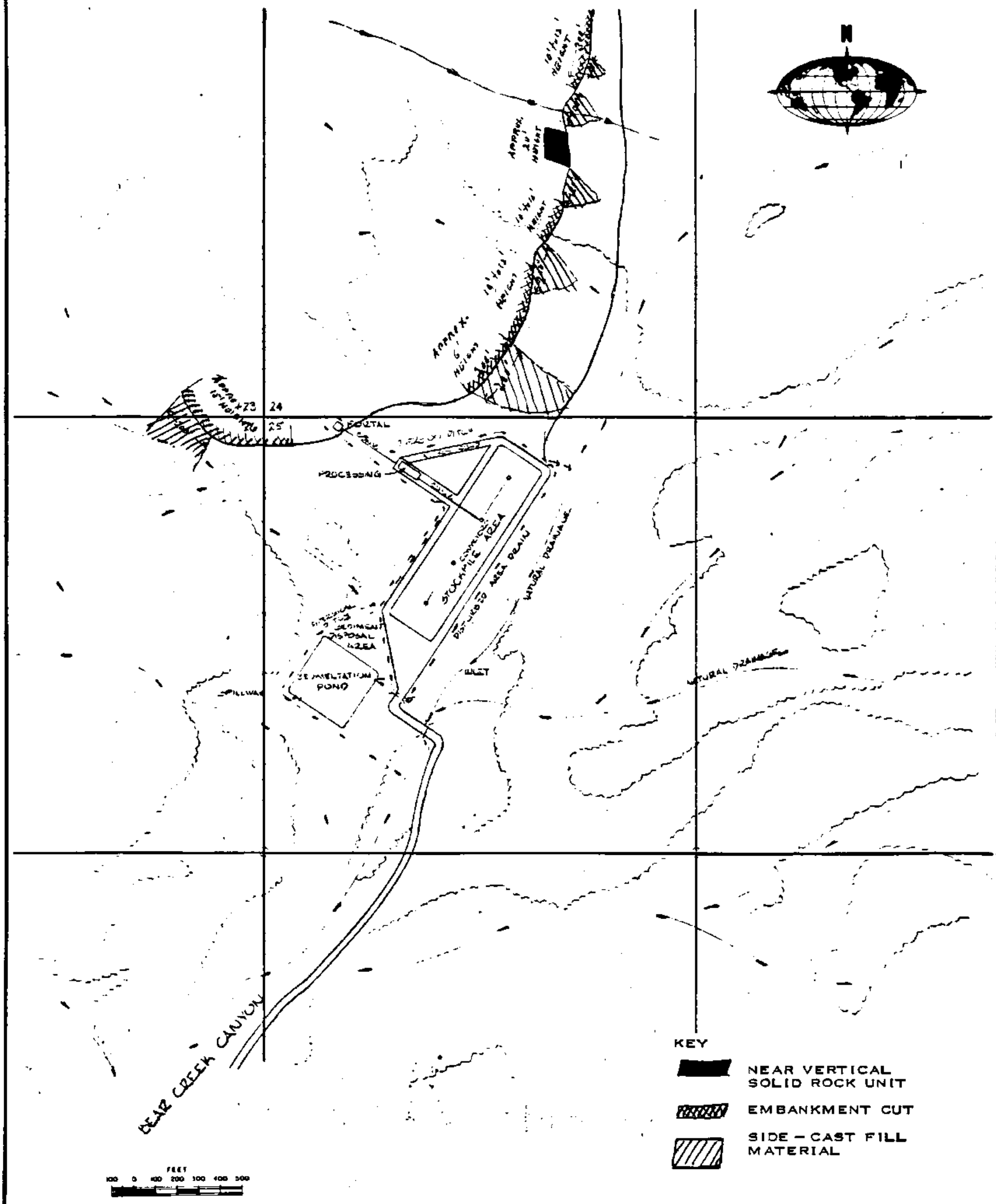
Douglas G. Beck
Staff Engineer

WJG/DGB/wb

Attachments"

Plate 1 - Plot Plan
Plate 2 - Slope Cross-Section
Computer Anlaysis Results

cc: Department of Natural Resources
Division of Oil, Gas and Mining (2)



PLOT PLAN

REFERENCE
ADAPTED FROM PRINT
SUPPLIED BY OTHERS.

DAMES & MOORE

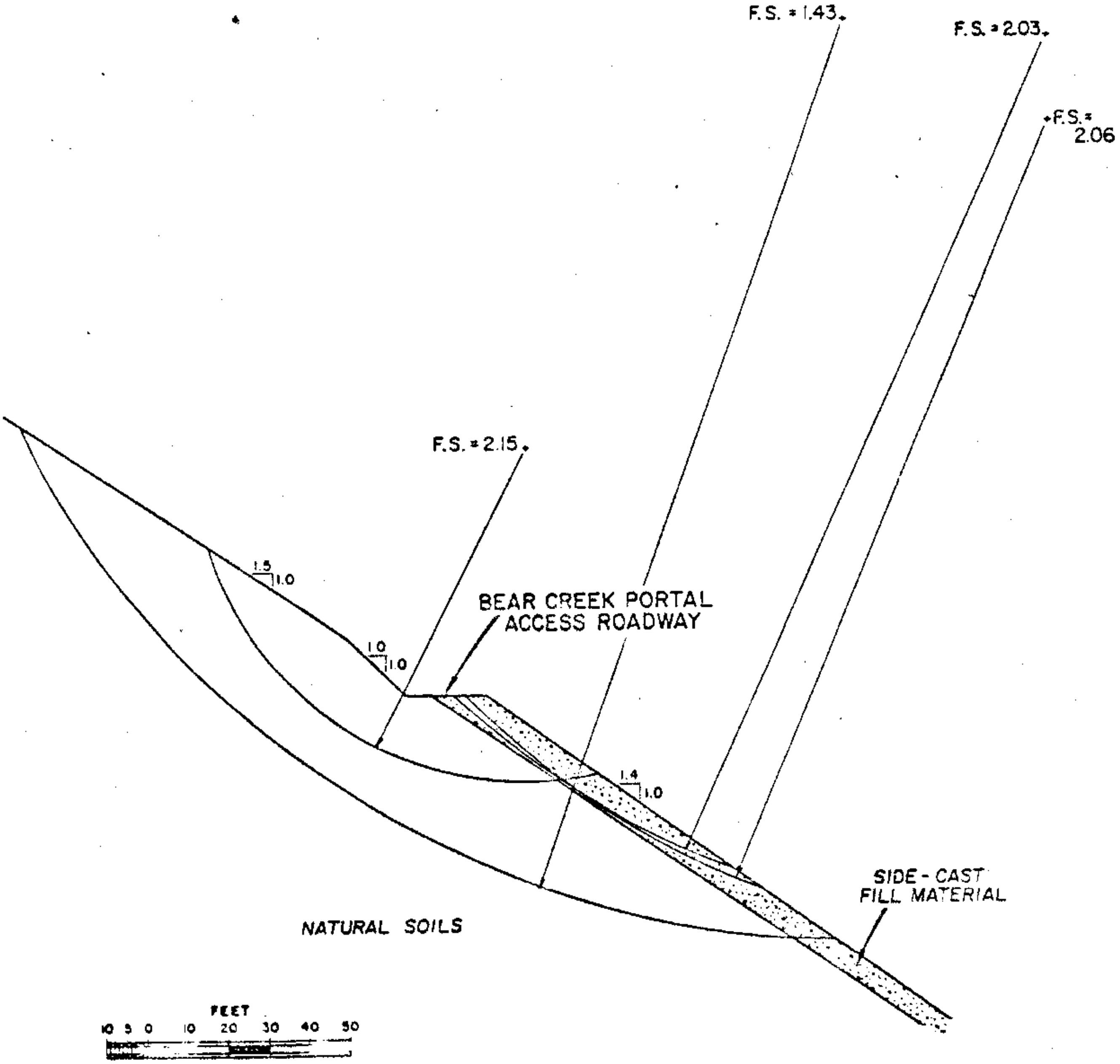
PLATE 1

REVISIONS BY ____ DATE ____

FILE ____

BY ____ DATE ____
CHECKED BY ____

6



SLOPE CROSS SECTION

DAMES & MOORE

SLOPE STABILITY ANALYSIS - SIMPLIFIED BISHOP'S METHOD

DATE OF LAST REVISION - DEC 11 78

DATE RUN - 02/19/81 TIME RUN - 19.00.45

0546101206 6093 GMB 022081 STABILITY ANALYSIS CUTSLOPE PARTIAL FILL

****

DATA INPUT MODE = 1
EARTHQUAKE COEFFICIENT = 0.000
PORE PRESSURE IS DEFINED BY WATER LINE DATA
TOTAL NUMBER OF SOIL LINES = 6 NUMBER OF WATER LINES = 0
0SLOPE GEOMETRY DATA

LINE NO	LEFT-X	LEFT-Y	RIGHT-X	RIGHT-Y	SOIL DATA. WT BELOW LINE-PCF	FRICT.ANGLE(DEG) (OR C/P-RATIO**) ABOVE	BELOW	COHESION-PSF ABOVE	BELOW	PORE PRESSURE RATIO ABOVE	BELOW	NEW BELOW	NUU ABOVE	NUU BELOW
					120.0	0.00	26.00	0.0	700.0	0.000	0.000	0	0	0
1	1018.00	1190.00	1086.00	1134.00	120.0	0.00	26.00	0.0	700.0	0.000	0.000	0	0	0
2	1086.00	1134.00	1100.00	1120.00	120.0	0.00	26.00	0.0	700.0	0.000	0.000	0	0	0
3	1100.00	1120.00	1106.00	1120.00	98.0	0.00	26.00	0.0	350.0	0.000	0.000	0	0	0
4	1106.00	1120.00	1120.00	1120.00	98.0	0.00	26.00	0.0	350.0	0.000	0.000	0	0	0
5	1120.00	1120.00	1232.00	1040.00	120.0	26.00	26.00	350.0	700.0	0.000	0.000	0	0	0
6	1106.00	1120.00	1220.00	1042.00										

NOTE: IF(NEW.EQ.1) SOIL IS NEWLY PLACED AND DOES NOT CONSOLIDATE LAYERS WITH NUU=1
IF(NUU.EQ.1) SOIL WILL BE LOADED UNDER UNDRAINED CONDITIONS BY NEWLY PLACED LAYERS
VALUES MARKED WITH ** ARE C/P RATIOS FOR LAYERS WITH NUU=1

UNIT WEIGHT OF WATER = 62.40 NUMBER OF COLUMN LOADS = 0

MODE OF PROGRAM OPERATION = 3

CENTER VARIATIONS	MIN-X	MAX-X	MIN-Y	MAX-Y	DX	DY
	1240.00	1260.00	1250.00	1280.00	10.00	10.00

RADIUS TANGENTS MAX= 1058.00 MIN= 1062.00 INCR= 1.00

1

RESULTS

****

INTR NO	RAD	CENTER COORDINATES		CIRCLE	FACTOR OF SAFETY	SUMWS	SUM1	SUM2	XR	XL	ARC	NN	TRIAL
	N060.26	170.08	2										

TRM
RDY
EDIT,OLD,GMB
UNIEDIT 3.32 READY ? WIDTH=/132/*FIND:/TABUL/*P.1;*

TABULATION OF MINIMUM SAFETY FACTORS
(CRITICAL RADIUS IN PARENTHESES)

1

Y COORDINATES	X COORDINATES 1240.0	1250.0	1260.0
1280.0	1.802	2.111	2.026 ✓
	(222.)	(222.)	(219.)
1270.0	1.877	2.034	2.108
	(212.)	(212.)	(210.)
1260.0	1.953	2.114	2.065
	(202.)	(202.)	(202.)
1250.0	1.954	2.084	2.575
	(191.)	(188.)	(192.)

READY ? END
RDY-FOR
BYE
CT = 00.23 SU-A = 1.9
KCH = 7
D034008 LOG OFF. 19.04.00.

2/*FIND:/TABUL/*P.1;*

TABULATION OF MINIMUM SAFETY FACTORS
(CRITICAL RADIUS IN PARENTHESES)

Y COORDINATES	X COORDINATES 1210.0	1215.0	1220.0	1225.0	1230.0	1235.0	1240.0
1310.0	1.534	1.504	1.478	1.451	1.495	1.549	1.617
	(240.)	(244.)	(248.)	(252.)	(252.)	(252.)	(252.)
1305.0	1.512	1.486	1.431	1.467	1.515	1.569	1.646
	(237.)	(241.)	(247.)	(247.)	(247.)	(247.)	(247.)
1300.0	1.462	1.440	1.445	1.485	1.531	1.594	1.672
	(236.)	(240.)	(242.)	(242.)	(242.)	(242.)	(242.)
1295.0	1.449	1.427	1.460	1.501	1.552	1.619	1.701
	(233.)	(237.)	(237.)	(237.)	(237.)	(237.)	(237.)
1290.0	1.437	1.441	1.477	1.518	1.575	1.643	1.734
	(230.)	(232.)	(232.)	(232.)	(232.)	(232.)	(232.)
1285.0	1.426 ✓	1.456	1.491	1.538	1.595	1.670	1.766
	(227.)	(227.)	(227.)	(227.)	(227.)	(227.)	(227.)
1280.0	1.440	1.471	1.509	1.559	1.618	1.699	1.802
	(222.)	(222.)	(222.)	(222.)	(222.)	(222.)	(222.)
1275.0	1.455	1.485	1.528	1.577	1.645	1.727	1.836
	(217.)	(217.)	(217.)	(217.)	(217.)	(217.)	(217.)
1270.0	1.468	1.503	1.545	1.600	1.669	1.759	1.877
	(212.)	(212.)	(212.)	(212.)	(212.)	(212.)	(212.)

1

TABULATION OF MINIMUM SAFETY FACTORS
(CRITICAL RADIUS IN PARENTHESES)

Y COORDINATES	X COORDINATES 1140.0	1145.0	1150.0	1155.0	1160.0
1180.0	2.425	2.675	3.063	3.269	2.729
	(82.)	(82.)	(82.)	(81.)	(80.)
1175.0	2.536	2.819	3.262	2.883	2.744
	(77.)	(77.)	(75.)	(73.)	(75.)
1170.0	2.662	2.982	3.294	2.867	2.654
	(72.)	(72.)	(70.)	(68.)	(71.)
1165.0	2.811	3.167	3.041	2.703	2.479
	(67.)	(67.)	(67.)	(64.)	(67.)
1160.0	2.984	3.235	2.997	2.565	2.519
	(62.)	(60.)	(62.)	(60.)	(62.)

TABULATION OF MINIMUM SAFETY FACTORS
(CRITICAL RADIUS IN PARENTHESES)

Y COORDINATES	X COORDINATES 1120.0	1125.0	1130.0	1135.0	1140.0
1180.0	5.342	2.219	2.146 ✓	2.260	2.425
	(82.)	(78.)	(82.)	(82.)	(82.)
1175.0	5.061	2.173	2.225	2.352	2.536
	(77.)	(74.)	(77.)	(77.)	(77.)
1170.0	2.181	2.220	2.315	2.456	2.662
	(71.)	(72.)	(72.)	(72.)	(72.)
1165.0	2.241	2.314	2.421	2.577	2.811
	(67.)	(67.)	(67.)	(67.)	(67.)

Appendix 3-F (cont)

5/10/85

STABILITY ANALYSIS

HIGHWALL STABILITY

Highwalls at the site face south, southeast, and east. The highwalls are nearly vertical, with an average slope of IV:2H, or 80.

The highwall stability analysis is based on a rotational shear analysis using the Hoek method. Compressive strengths of materials in the Blackhawk Formation are highly variable, ranging from 290 psi for soft shale to more than 20,000 psi for certain sandstones, An average value of 5,000 psi has been used for this analysis, This is a very conservative figure, based on the relative proportions of sandstones and shales in the exposed highwalls.

There are 2 joint sets typically found in this area. the major set has a strike of about N 10 deg E and dips 80 deg to vertical. The minor set has a strike of approximately N 70 deg W and also dips greater than 80 deg. The bedding in the highwall area is nearly flat.

Cohesion can be calculated from compressive strength by the following formula:

$$C_i = \frac{Co}{2}\tan\left(45-\frac{\theta}{2}\right);$$

where: C_i = Intact rock shear strength or cohesion

Co = Intact rock compressive strength

θ = Internal friction angle.

Using a typical internal friction angle of 45 deg for Wasatch Plateau rock types, and a 5,000 psi compressive strength, a cohesion or intact rock strength of approximately 1,000 psi is found. Since the 1,000 psi value is for intact or solid rock, the value must be adjusted to compensate for jointing and fracturing common to all rock masses. A method of relating fracture intensity and cohesion was developed by Stimpson and Ross-Brown and can be found in the article entitled, "Estimating the Cohesive Strength of Randomly Jointed Rock Masses", Mining Engineering, Vol. 31, No. 2, pp. 182-188. Based on this method and using a conservative figure of 4 joints per meter, a .065 factor is determined for calculating rock mass cohesion (C_m). Based on a C_i of 1,000 psi, C_m becomes 65 psi.

A typical or average rock mass bulk density of 155 lbs./ft^3 was selected for the analysis, and a slightly conservative, but commonly used value of 31 deg was selected for the rock mass sliding friction angle.

The following parameters were used with the Hoek slope chart (Hoek, E., and J.W. Bray, 1981, Rock Slope Engineering, Revised Third Edition, IMM, London):

H = Maximum Slope Height - 100 ft

θ = Slope Angle (average) - 80 deg

C_m = Rock Mass Cohesion - 65 psi

ϕ = Rock Mass Friction Angle - 31 deg

γ = Rock Mass Bulk Density - 155 $lbs./ft^3$

Plotting the above parameters on the Circular Failure Charts Nos. 1 and 5 (Figure 3F-1 and 3F-2), it can be seen that the projected highwalls will have a safety factor or 2.61 under dry conditions and 2.40 under saturated conditions. It should be noted that the safety factors exceed the required 1.5 safety factor.

EMBANKMENT STABILITY

Embankment or backfill will be placed in lifts not to exceed 36 in. and will be compacted to 90 pct of the laboratory obtained T-99 Standard Proctor. Slopes will not exceed IV:1.5H or 33.7 deg. Soil properties are based on those used in the "Slope Stability Analyses for the Bear Creek Portal and Access Road", by Dames and Moore, February 20, 1981, and the "Geotechnical Consultation, Bear Creek Portal", by Dames and Moore, December 29, 1980, and the "Bear Canyon Mine Site, Sedimentation Pond "A" Stability Analysis", by

Horrocks and Corollo Engineers on July 12,1984.

Based on the proposed plan, and the results of samples taken during the above studies, the following parameters were established for the safety factor calculations:

a. H = Embankment Height = 30 ft; this represents the maximum height of compacted embankment proposed in the plan;

b. θ = Slope Angle = 33.7 deg; this is the maximum slope (IV:1.5H) proposed for the reclaimed embankments.

c. C_m = Soil Cohesion @ 90 pct Compaction = 4.375 psi; Actual Cohesion tests on compacted native material at this site showed a cohesion value of 700 psf at a density of 118 lbs./ft^3 and a compaction value ranging from 89 pct to 94 pct. (See Sediment Pond "A" Stability Analysis, by Horrocks & Corollo Engineers, July 12, 1984.) To provide for maximum safety in the calculation, the cohesion factor is reduced by the compaction factor.

700 psf X 0.9 = 630 psf = 4.375 psi

d. ϕ = Friction Angle = 26 deg; This angle is based on the measurements taken and reported in the Feb. 20, 1981 Dames & Moore Slope Stability Analysis on the Bear Creek

Portal and Access Road.

e. γ = Rock Mass Bulk Density (90 pct) = 108 lbs./ft^3; Once again, this is a conservative number, established by taking actual values of 118 to 120 lbs./ft^3 as reported in the above reference stability analysis, and allowing for 90 pct compaction - 120 X 0.90 = 108 lbs./ft^3.

A rotational shear analysis was performed using the Hoek method to determine stability of the backfilled slopes. The following parameters were used for the slopes:

H = Embankment Height - 30

θ = Slope Angle - 33.7

C_m = Soil Cohesion @ 90 pct Compaction - 4.375 psi

ϕ = Friction Angle - 2

γ = Rock Mass Bulk Density (90 pct) - 108 lbs./ft^3

Based on the above criteria, backfilled slopes are found to have an expected safety factor of a maximum of 2.21 for dry conditions to a minimum of 1.68 for saturated conditions. Both cases exceed the required static safety factor of 1.3. It should also be noted that the previous slope stability analysis by Dames & Moore resulted in static safety factors ranging from a minimum of 1.43 to 2.15 for side-cast cut and fill material in this area.

Note: The embankment compaction factors and cohesion values are based on previous tests performed in the Bear Canyon area. Although the tests were not site specific, they were run on the existing soils which are the same as those to be used in reclamation. The values used for rock compressive strengths were taken from rock parameters typical of the Blackhawk Formation in the Wasatch Plateau, and commonly used and accepted for this type of calculations.

If it is determined necessary, Co-Op will commit to taking site specific tests on the soils and highwall rock to further verify the factors of safety, these tests would be performed prior to reclamation, at the discretion of the Division.

REMOVAL OR REDUCTION OF HIGHWALLS

Due to the laws requiring removal of highwalls constructed following 1977, the Division has directed Co-Op to recover all highwalls. Plates 3-2 show existing highwalls (Plates 2-4) are recovered during reclamation.

Figure 3F-1
(DRY CONDITIONS)

CIRCULAR FAILURE CHART NUMBER 1

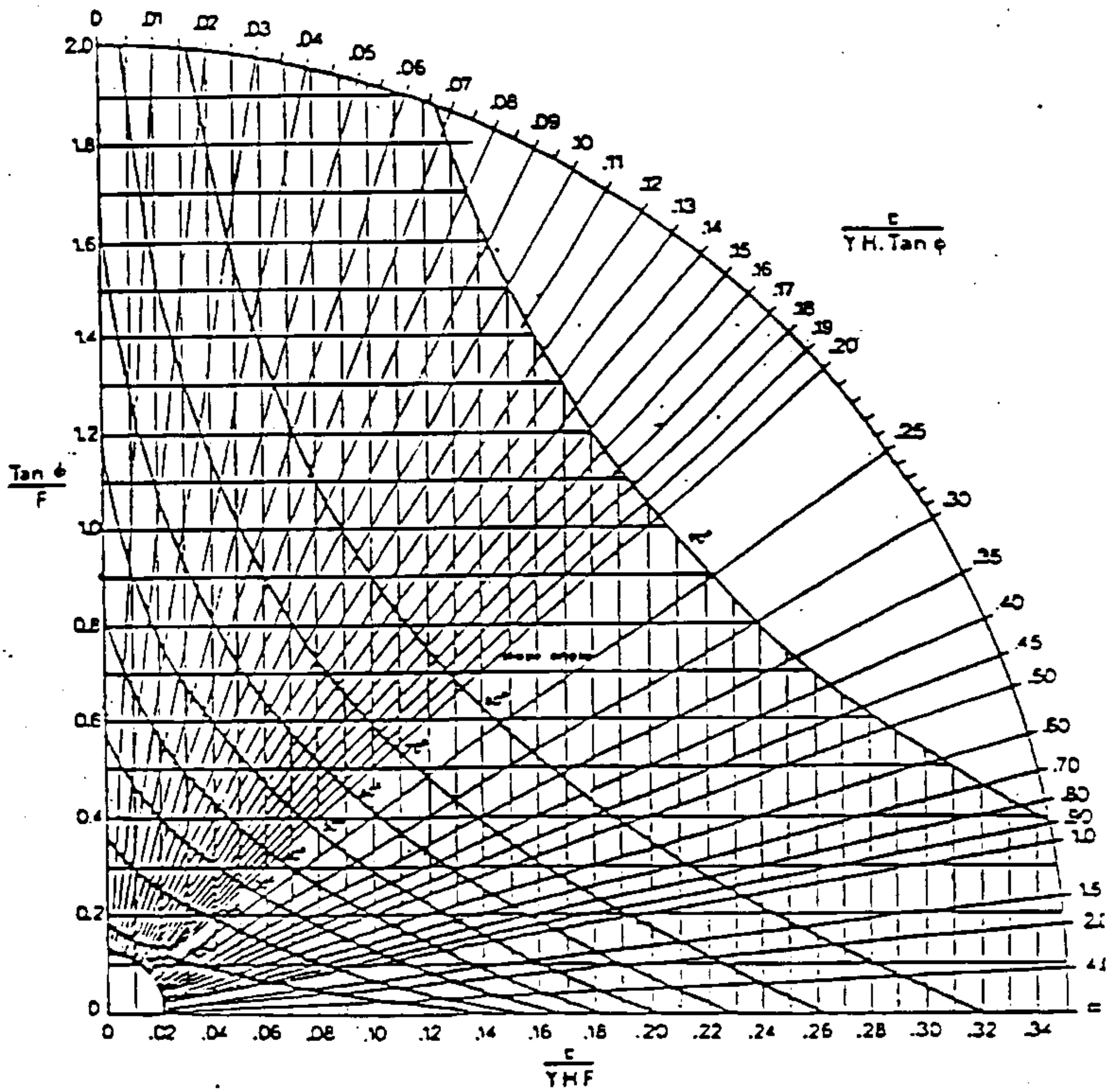
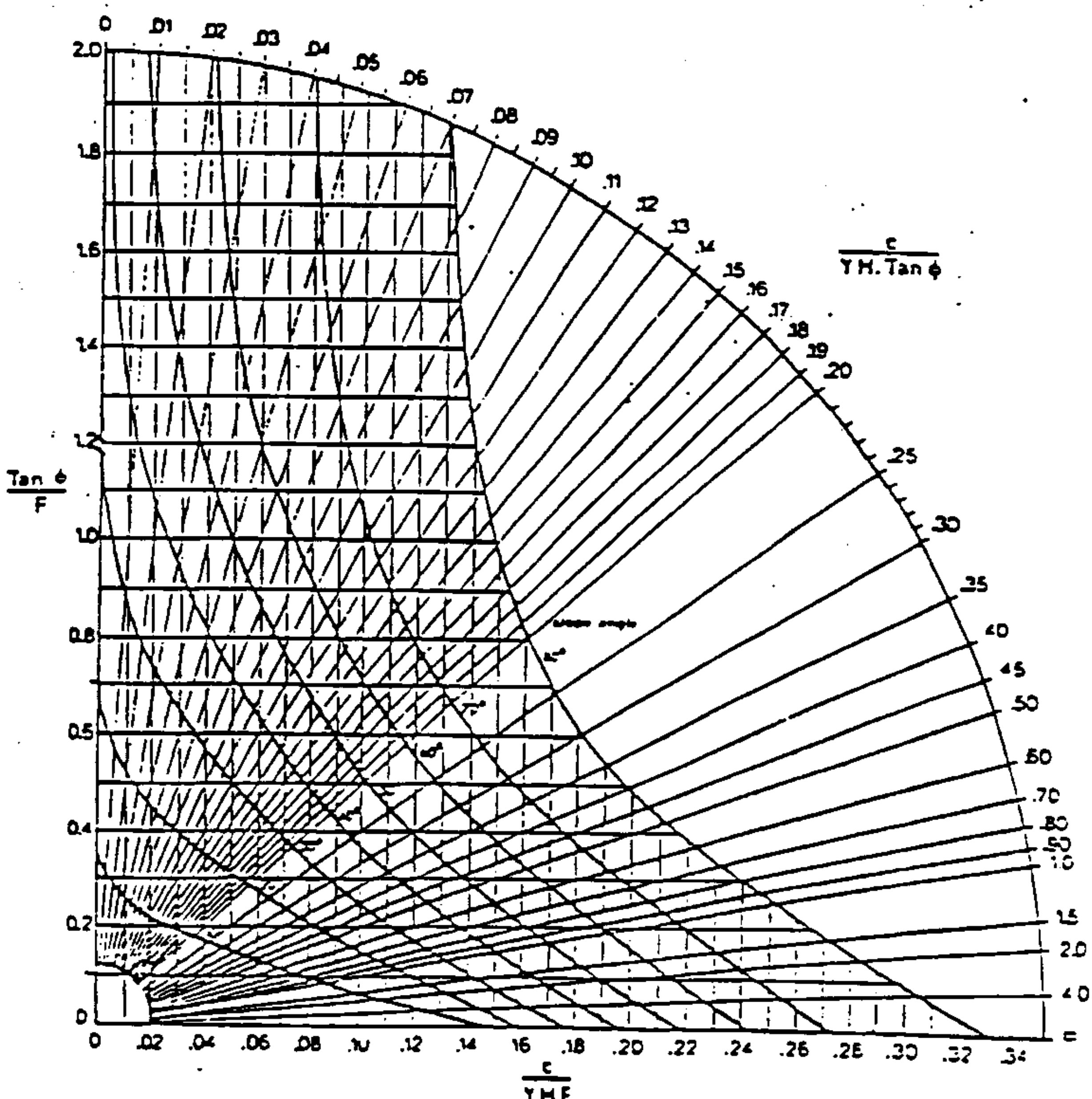


Figure 3F-2

(SATURATED CONDITIONS)

CIRCULAR FAILURE CHART NUMBER 5

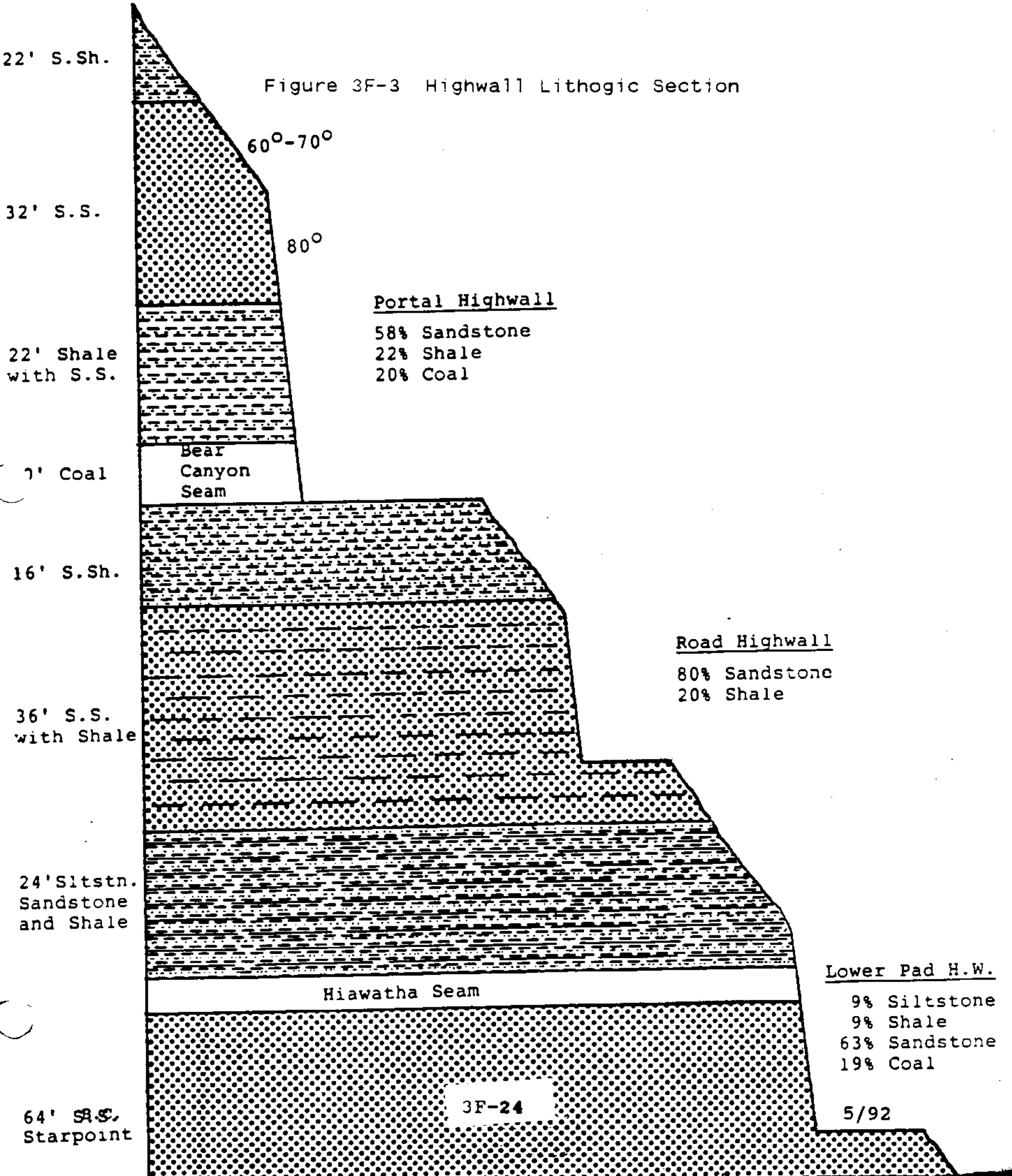


BY D. Guy DATE 8/15/85 SUBJECT Highwall Lithologic Section SHEET NO. .... OF ....

CHKD. BY .... DATE .... JOB NO. ....

Scale: 1"=20'

Figure 3F-3 Highwall Lithogic Section



5/92

RECLAIMED TANK SEAM PORTAL ACCESS ROAD

SLOPE STABILITY ANALYSIS

DAMES & MOORE

127 SOUTH 500 EAST, SUITE 300, SALT LAKE CITY, UTAH 84102-1959
(801) 521-9255 FAX: (801) 521-0380

May 10, 1994

CO-OP Mining Company
P.O. Box 1245
Highway 31
Huntington Canyon
Huntington, Utah 84528

Attention: Mr. Charles Reynolds
Mining Engineer

Report
Stability Analysis for Reclaimed
Tank Seam Portal Access Road
Job No. 27437-001-162

INTRODUCTION

Dames & Moore performed stability analyses for construction and reclamation of the Tank Seam Portal Access Road in 1993. Minor revisions were incorporated into that report, dated September 16, 1993 for access road construction, and an updated report has been issued. This report incorporates updated reclamation concepts and replaces the original stability analysis for the reclaimed Tank Seam Portal Access Road, dated September 22, 1993.

STABILITY ANALYSIS

This report presents stability analyses for the anticipated configuration of the Reclaimed Tank Seam Portal Access Road. The general location of the proposed access road is presented on Plate 1. It is assumed that the access road excavation will be reclaimed to approximately the same slope as the topography adjacent to the access road alignment. Backfill materials will be derived from the fill sections of the road and from adjacent slopes during the reshaping. Materials to be used during reclamation of the access road will be native soils and no additional materials from offsite borrow sources are anticipated. Boulders obtained during initial road construction that are not incorporated into reclamation fill and that cannot be broken down into smaller fragments will be placed on stable flat areas of the mine site.

A stability analysis of the proposed reclaimed slope was performed utilizing a two dimensional, limit equilibrium stability program called PCSTABL5. An automatic search routine was employed to determine the failure surfaces with the lowest factors of safety. Only circular failure surfaces were evaluated. A natural slope of 35 degrees was modeled considering dry conditions.

The analysis of the cut slope section considered one horizontal to two vertical (1H:2V) cuts. Bedrock was modeled to be present 6 feet vertically below the ground surface and to trend parallel to the natural cut. The roadway section cut was backfilled to conform to the natural existing slopes above and below the access road excavation. The small fill section, which includes the safety berm, was left in place in the stability analysis model. However, it could be removed during reclamation activities. Removal of the berm would not decrease the stability of the slope. Plate 2 presents the configuration modeled, the input material properties, and the ten failure surfaces with the minimum safety factors. A minimum factor of safety of 1.8 was determined for the input configuration. The "arrows" on Plate 2 indicate the failure surface with the lowest safety factor.

The fill material placed in the road cuts should be compacted in lifts not exceeding 18 inches in depth and compacted by heavy machinery during placement. All rock fragments in excess of 18 inches should be removed from the initial lifts of the fill. Rock fragments obtained during road construction and incorporated in the fill should be placed in a manner to minimize void space. During placement of the fill, boulder sized rock fragments in excess of 18 inches could be incorporated into upper lifts of the fill provided the majority of the fragments are well embedded in the fill and the material adjacent to these rock fragments is properly compacted. The surface of the reclaimed ground that is devoid of protruding rock fragments should be scarified to a minimum depth of 12 inches to reduce surface compaction and to aid in the re-establishment of vegetation.

All of the existing gullies for slope drainage should be re-established to their natural configuration. Since the stability of the reclaimed slopes will be influenced by the degree of saturation of the existing soils, surface drainage must be channeled to prevent or at least minimize runoff over the reclaimed slopes.

Questions have been raised concerning the stability of the scarified surface of the reclaimed slopes, particularly if topsoil comprises the majority of the scarified material. To evaluate this scenario, a reclaimed slope of 35 degrees with simulated 18 inch lifts was modelled. The friction angle of the outer 12 inches of the slope was reduced to 30 degrees to mimic scarified conditions. We understand that an erosion control/revegetation blanket similar to Excelsior S-2 or equivalent will be placed over the scarified slope surface and stapled into scarified material to minimize erosion potential and to enhance slope stability. This blanket was also incorporated into the model and a minimal tensile strength utilized. The modelled configuration, input properties, and the ten failure surfaces with the minimum factors of safety are presented on Plate 3.

The analysis indicates that the scarified material will achieve minimum factors of safety provided proper construction techniques are utilized and the erosion control/revegetation blanket is properly placed and adequately attached to underlying soils. Scarification and placement of the blanket should be coordinated such that vegetation can begin to develop prior to spring runoff.

Based on our slope stability analysis and observations made during our reconnaissance visit, it is our opinion that the reclaimed fill slopes, if properly constructed, will perform similar to or better than the natural existing slopes in the area of the proposed Tank Seam Portal Access Road.

Again, we are pleased to be able to assist you with the expansion of the Bear Creek Mine. If you have any questions concerning this report, our previous reports, or if we can assist you in any other way please call at your earliest convenience.

oOo

The following Plates are attached and complete this report:

Plate 1 - Plot Plan
Plate 2 - Reclaimed Slope Cross-Section
Plate 3 - Reclaimed Slope Scarified Section

LICENSED PROFESSIONAL ENGINEER
93-180048-2202
RUSSELL L.
OWENS
STATE OF UTAH

Sincerely,

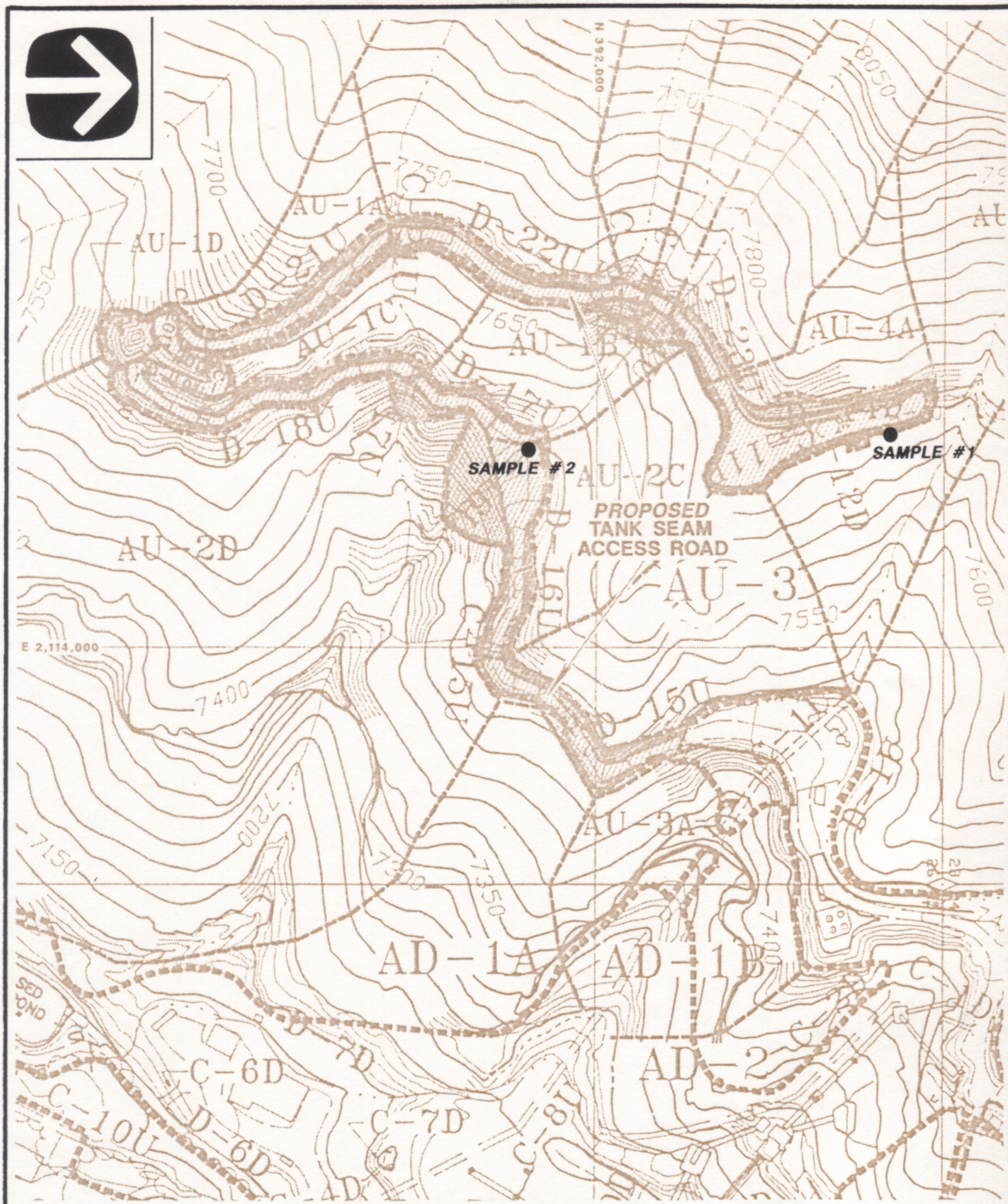
DAMES & MOORE, INC.

C. Charles Payton

C. Charles Payton, C.E.G.
Associate

Russell L Owens

Russell L. Owens, P.E.
Professional Engineer
State of Utah



100 0 100 200

SCALE IN FEET

AD-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED THROUGH SEDIMENT PONDS OR ALTERNATE SEDIMENT CONTROL STRUCTURES

AU-1 INDICATES DRAINAGE AREAS THAT ARE DIVERTED BY DITCH AND/OR CULVERT TO OFF-SITE WITH LIMITED OR NO SEDIMENT CONTROL

CO-OP MINING CO.
PLOT PLAN
BEAR CANYON MINE

REFERENCE-
ADAPTED FROM DRAWING ENTITLED, "WATERSHED MAP; BEAR CANYON," BY CO-OP MINING CO., HUNTINGTON, UTAH, PLATE 7-5, DATED 5-6-91.

Dames & Moore

PLATE 1

FILE 27437-002-162 BY ______ DATE ______ CHECKED BY ______ DATE ______

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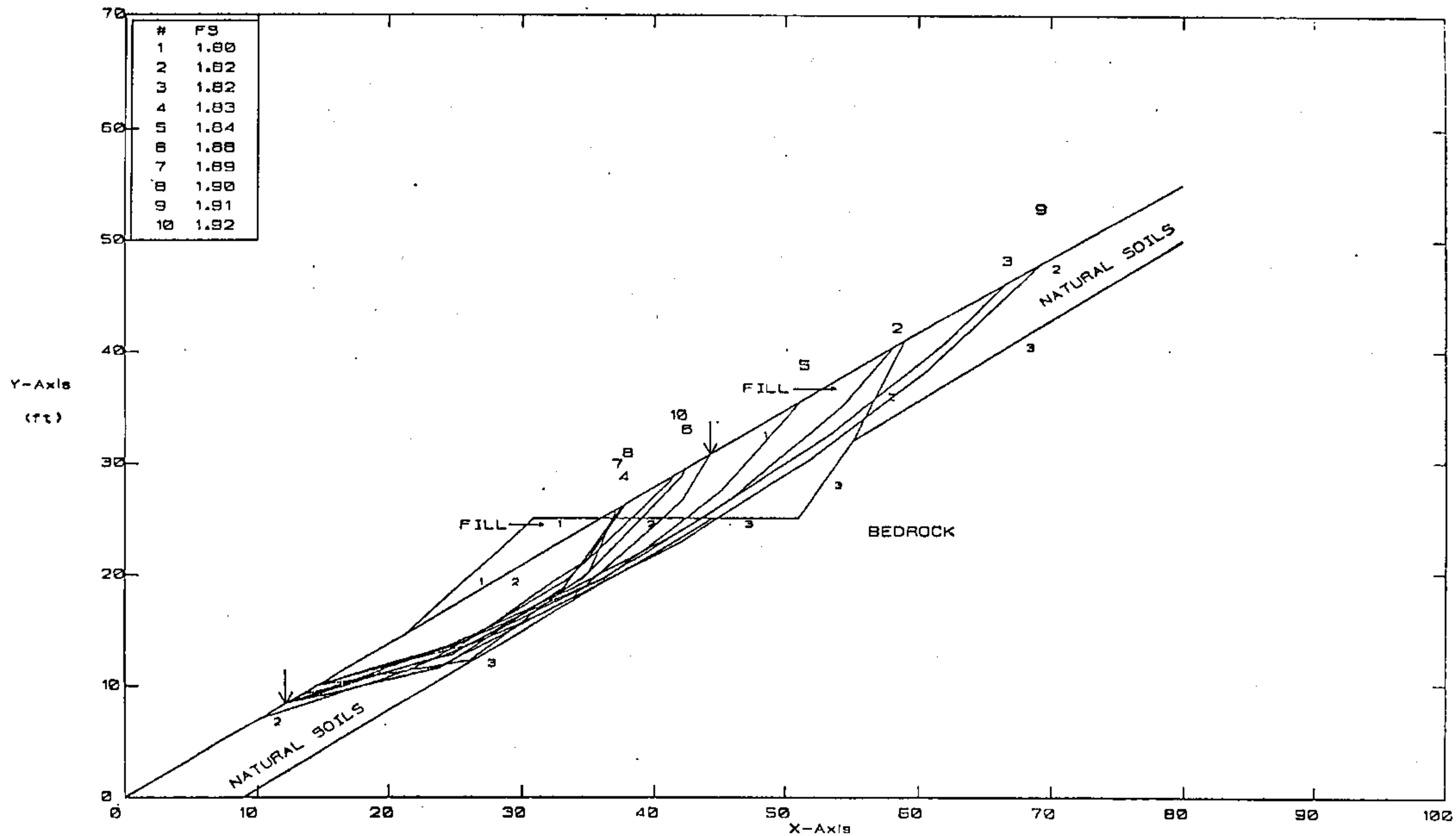
CO-OP Mine 1H:2V Cut slope, Reclaimed

Ten Most Critical Failure Surfaces



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)
1	125	130	180	36
2	120	125	180	32
3	130	140	500	38

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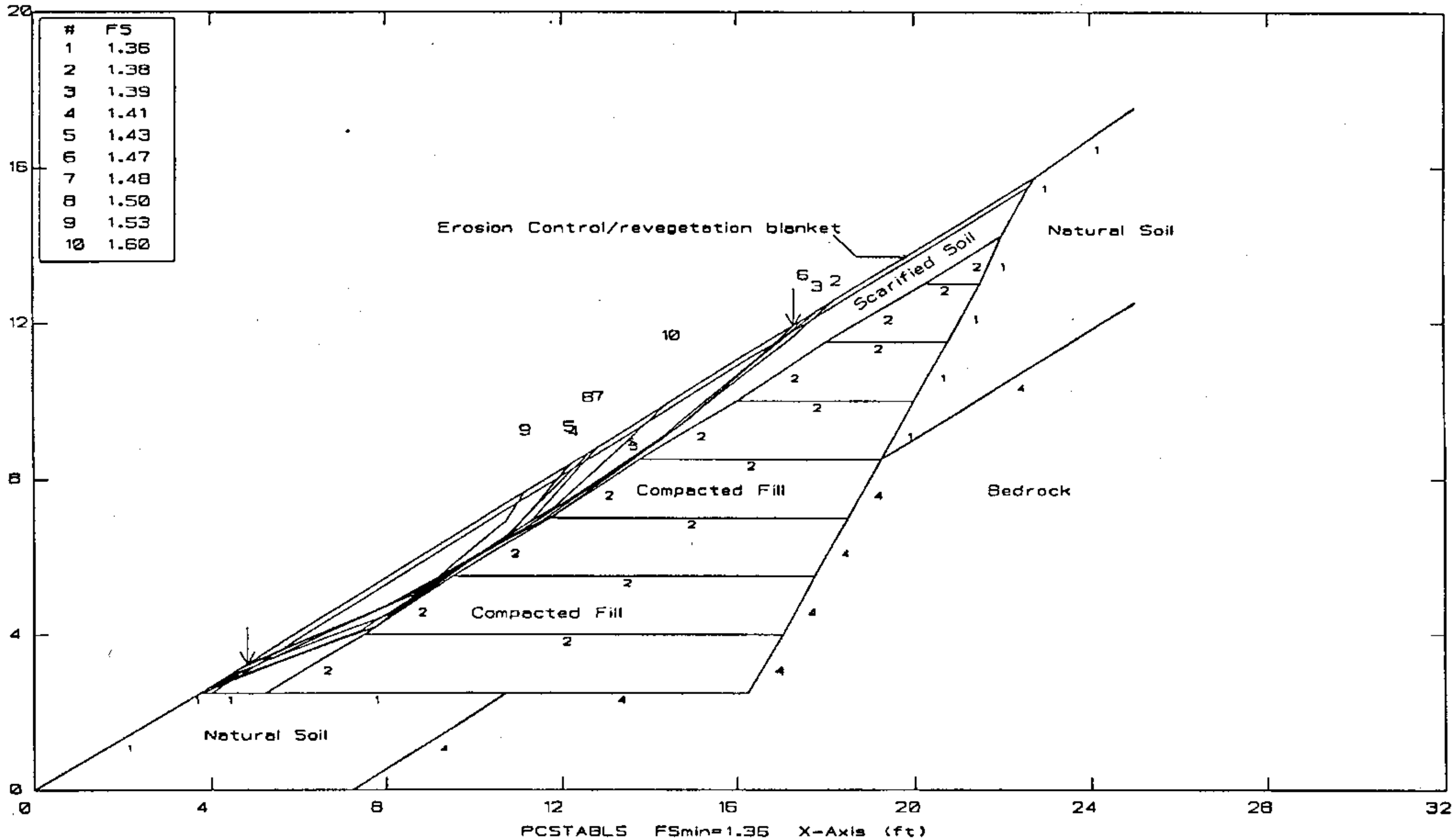
PLATE 2

FILE ______ BY ______ DATE ______ CHECKED BY ______ DATE ______

CO-OP Mine 1H:2V Cut slope, Scarified Reclaimed Slope

Ten Most Critical Failure Surfaces



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Material Type
1	120	125	180	32	Natural Soil
2	125	130	180	36	Compacted Fill
3	110	115	0	30	Scarified Soil
4	130	140	500	38	Bedrock
5	1	1	100	0	Erosion Control/Revegetation Blanket

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PLATE 3